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Header tube for a heat exchanger and method for the production of same

The invention relates to a header tube for a heat exchanger, with one or more slots for the insertion of a respective flat tube, said slots being introduced by punching with no inner die or by internal high-pressure forming, and to a method for the production of a header tube of this type. An important field of use is heat exchangers in the form of evaporators and condensers or gas coolers of motor vehicle air-conditioning systems.

Patent Specifications EP 0 198 581 B1 and US 5,052,480 disclose header tubes, each with a row of transverse slots, into which are inserted flat-tube ends of a heat exchanger block constructed from flat tubes arranged in parallel. Due to the transverse position of the slots, the header tube diameter must be kept larger than the slot length. The header tubes have a tube-wall thickness which is smaller by a multiple than their diameter. Due, inter alia, to this small tube-wall thickness, as regards the header tubes of EP 0 198 581 B1, indentations of the header tube occur in the regions of the slots and form inwardly bent intrusions, the tube outside diameter being about one and a half times larger outside the slot region than in

the slot region.

In a header tube production method described in the laid-open publication DE 43 34 203 A1, transverse slots in the form of inwardly bent intrusions are introduced into a header tube by punching assisted by an inner die, for which purpose an inner die is pushed into the header tube and the slots are punched into the header tube wall from outside by means of a suitable ram.

Alternatively to transverse slots, it is known to provide header tubes with slots which run parallel to or at an acute angle to the tube longitudinal axis and into which twisted flat-tube ends are inserted, see for example, Patent Specification US 3,416,600 and the laid-open publications EP 0 845 648 A2 and DE 197 29 497 A1.

The technical problem on which the invention is based is to provide a header tube of the type mentioned in the introduction, which can be produced at relatively low outlay and is also suitable, in particular, for applications involving a high pressure load, such as for CO_2 air conditioning systems of motor vehicles, and an advantageous method for the production of such a header tube.

The invention solves this problem by the provision of a header tube having the features of Claim 1 and of a method for header tube production having the features of Claim 4 or 5.

In the header tube according to Claim 1, the ratio of the tube outer radius to the tube-wall thickness has a value lower than five, that is to say, with respect to its tube outer radius, the header tube has a comparatively large tube-wall thickness which makes it suitable for applications involving a high pressure load, such as occur, for example, in motor vehicle air-conditioning systems which operate with CO_2 as refrigerant. In particular, tube-wall thicknesses of between 1.8 mm and 2.5 mm may be provided. The header tube with this large tube-wall thickness can be provided at relatively low outlay, by punching with no inner die or by internal high-pressure forming, with elongate slots, into which associated flat-tube ends of a heat exchanger can be inserted and can be sealingly soldered or secured in a gastight manner in another way.

In an advantageous development of the invention, according to Claim 2 a material with a hardness of between 35 H_v and 80 H_v is selected for the header tube.

In a further refinement of the invention, according to Claim 3, the slots are formed by inwardly bent intrusions, in such a way that the ratio of the tube outside diameter outside the slot region to that in the slot region is between 1.02 and 1.5.

In the header tube production method according to Claim 4, one or more slots are introduced into the header tube by punching with no inner die or by internal high-pressure forming and are oriented parallel to or at an acute angle to the header tube longitudinal axis. A header tube produced in this way is particularly suitable for heat exchangers, in which use is made of flat tubes with twisted ends which, as a result of the twisting, are oriented at a corresponding angle to the header tube longitudinal axis.

In the header tube production method according to Claim 5, in order to form the header tube, first a flat piece, which may be solder-plated, if required, is bent into a blank, the longitudinal gap which has thereby remained being subsequently sealingly soldered or sealingly welded. The slots required for the insertion of heat exchanger flat tubes are introduced, by punching with no inner die, selectively either already into the flat piece or only into the blank bent out of the flat piece, before or after the longitudinal gap is

sealingly soldered or sealingly welded.

In a further refinement of this production method, according to Claim 6, a solder-plated flat piece is used so that a correspondingly solder-plated header tube is then obtained, thus making it easier for the longitudinal gap and/or flat-tube ends inserted into the slots to be sealingly soldered. In a further refinement of this measure, according to Claim 7, the seal-soldering of the longitudinal gap is carried out in a common soldering operation, in which the remaining components of the heat exchanger are simultaneously soldered together, so that, overall, only one complete soldering operation is necessary for the manufacture of the heat exchanger.

In a further refinement of the header tube production method according to the invention, according to Claim 8 punctiform heat treatment and/or mechanical weakening is provided at the points on the header tube at which the slots are to be introduced, thus making it easier for the slots to be introduced with no inner die.

Advantageous embodiments of the invention are illustrated in the drawings and are described below.
In the drawings:

Figure 1 shows a diagrammatic side view of a detail of a header tube with slots introduced parallel to the tube longitudinal axis,

Figure 2 shows a sectional view along the line II-II of Figure 1,

Figure 3 shows a top view of a detail of a flat piece which can be used for producing the header tube of Figure 1,

Figure 4 shows a side view of the header tube blank obtained by bending round the flat piece of Figure 3,

Figure 5 shows a side view of a detail of a header tube with two slots lying circumferentially in contact next to one another, and

Figure 6 shows a cross-sectional view of a header tube with two separate longitudinal header ducts.

The header tube 1 shown as a detail in Figures 1 and 2 is provided circumferentially, that is to say on its tube outer surface, with a row of slots 3a, 3b, 3c, 3d, 3e, 3f which succeed one another in the direction of the tube longitudinal axis 2 and have an elongate

configuration matched to the cross-sectional shape of flat-tube ends to be inserted. Said slots run with their longitudinal extent parallel to the tube longitudinal axis or tube outer surface line 2 and succeed one another at equal short intervals so as to form corresponding web regions 4a, 4b, 4c, 4d, 4e. It goes without saying that, if required, that is to say depending on the succession of flat-tube ends to be inserted of a heat exchanger flat-tube block configuration used in each case, any other succession of slots is possible, for example, a sequence of pairs of slots having a wider interval and each consisting of two closely adjacent slots.

The slots 3a to 3f can be introduced by means of a punching operation, in which the header tube 1 is surrounded by an outer die divided in two, the lower die half of which carries the header tube 1 and the upper die half of which has a corresponding number of slots which are arranged at intervals and through which associated punching rams penetrate and thereby "tear" the slots 3a to 3f into the header tube 1 as inwardly directed intrusions. Alternatively, the introduction of the slots may also be carried out partially by means of suitable rams and also with the header tube 1 being guided only partially on the outer circumference. As can be seen in more detail from Figure 2, owing to the

inwardly bent-round intruded slots 3a to 3f, the header tube 1 has in the respective slot region a tube outside diameter D_1 which is smaller than the tube outside diameter D outside the slot regions, that is to say level with the webs 4a, 4b, 4c. The term "outside diameter" is in this case to be understood in the wide sense as designating in general the transverse extent, even in the case of noncircular cross-sectional shapes. It is shown that the "tearing" or punching of the slots 3a to 3f should preferably be carried out in such a way that the ratio of the tube outside diameter D outside the slot regions to the tube outside diameter D_1 in the slot regions is between about 1.02 and about 1.5. The introduction of the slots 3a to 3f may be influenced or facilitated by the header tube 1 previously being heat-treated in a punctiform manner at the respective points or by mechanical weakening of the tube wall being provided at these points. As a further alternative manufacturing method, the slots may also be introduced by means of internal high-pressure punching.

As is also evident from Figure 2, the header tube 1 has a relatively large wall thickness s in relation to its diameter D, so that it is also suitable for applications involving a high pressure load. The header tube 1 can therefore also be used, in particular, for heat exchangers such as evaporators and gas coolers, of

CO_2 air-conditioning systems which are increasingly provided for use in motor vehicles. The tube-wall thickness s is typically larger than 1.0 mm and is preferably in the range of between about 1.3 mm and 2.5 mm. With respect to the tube outside diameter D or to the tube radius D/2, it proves advantageous if the ratio D/2s or the tube radius D/2 to the tube-wall thickness s is kept lower than five and is preferably between about two and five. Furthermore, it proves beneficial to select a material for the header tube with a material hardness of between about 35 H_v and about 80 H_v, in particular for use in a heat exchanger of a CO_2 air-conditioning system.

Associated flat-tube ends, in particular flat-tube ends twisted through 90°, may be inserted into the slots 3a to 3f in a way known per se and be connected in a gastight manner. For this purpose, the slots 3a to 3f may be provided with suitable tube introduction slopes, thus making it easier to receive a gastight connection by means of a subsequent seal soldering operation. For seal-soldering, the header tube may be solder-plated or suitable solder preforms may be used. The prior solder-plating of the header tube may be carried out according to a current plating method or else by means of a CD method or by galvanizing. Alternatively, the slots introduced into the header tube may also be introduced

into the header tube without an inwardly directed intrusion region and without introduction sloping. Depending on the tube-wall thickness and tube strength and on the moment of resistance during the introduction of the slots 3a to 3f, a more or less pronounced deformation forming an intrusion is formed parallel to the tube extent and, due to its trough shape, keeps the solder in the region to be soldered, when the flat-tube ends inserted into the slots 3a to 3f are being sealingly soldered. The seal-soldering of the inserted flat tube ends may be carried out in a single soldering operation in which, at the same time, the entire construction, for example a tube/rib block construction and the associated exchanger is soldered together. By means of this manufacturing method, both flat tube condensers or flat tube gas coolers and evaporators of given types can be produced, for example those with a block consisting of rectilinear or of serpentine flat tubes. Suitable header tubes of the present type are then in each case arranged laterally on the block in order to distribute the refrigerant of the air-conditioning system to the flat tubes and to collect it from the flat tubes.

The header tube 1 may be manufactured, as an initially unplated header tube blank, by drawing and subsequent optional plating. Another manufacturing method is

illustrated in Figures 3 and 4. In this type of production, the flat tube 1 is manufactured from a flat material 5, which, if desired, may already be solder-plated. As illustrated in Figure 3 by bending arrow B, the flat piece 5 is bent parallel to its longitudinal axis 5a into a round-tube blank, shown in Figure 4. As is also evident from Figure 4, where the round-tube blank 6 is concerned, the two previous flat-piece longitudinal sides 7a, 7b are located opposite one another so as to form a narrow longitudinal gap 8. The longitudinal gap 8 is then closed in a gastight manner by welding or soldering in a subsequent manufacturing step. The seal-soldering of the longitudinal gap 8 is carried out by means of flux in a special soldering operation or in a common operation together with the seal-soldering of flat-tube ends which are inserted into slots in the blank 6 functioning in the finished state as a header tube. In particular, a single complete soldering operation may be provided, in which the soldered connections and also all the other soldered connections of the components necessary for constructing a corresponding heat exchanger are made. The insertion slots for the flat-tube ends may, depending on the application, be introduced already into the flat piece 5 or only into the round-tube blank 6 before or after the gastight closing of the longitudinal gap 8. In this case, the row of slots, as

is shown in Figure 1 is preferably located diametrically opposite the longitudinal gap 8.

Instead of the row, shown in Figure 1, of slots introduced in the tube longitudinal direction and in a longitudinal mid-plane of the header tube 1, the elongate slots required for the insertion of flat-tube ends may also be introduced in another way, for example as eccentric slots, which are introduced, offset laterally to the longitudinal mid-plane or outer surface line of the header tube or as inclined slots, which are introduced, inclined at an angle of more than 0° and less than 90° to the tube outer surface line or longitudinal mid-plane of the header tube. By the tube ends thereby issuing into the header tube not transversely to the tube longitudinal direction, but parallel to or at an inclination to the latter, the inside diameter of said header tube can be kept smaller than the flat-tube width. This is conducive to the stability of the header tube under pressure and, as compared with flat tubes entering transversely, makes it possible to have a reduction in volume of the header tube and consequently of the refrigerant quantity necessary for the air-conditioning system.

A further variant is illustrated in Figure 5. In the header tube 9 shown as a detail there, two

circumferentially adjacent slots 11a, 11b are provided, which are combined to form a corresponding double slot in that they are longitudinally in contact with one another along the tube outer surface line 10. Two flat-tube ends lying closely against one another can be inserted into this double slot in a gastight manner. As a further alternative slot configuration, a row of slots similar to that of Figure 1 is provided, in which, however, the slots are not arranged at intervals from one another but butt with their narrow sides against one another.

Apart from the circular cross section, other header tube cross sections are also possible, depending on the application, for example a rectangular or square, semicircular or oval cross section. Moreover, the header tube according to the invention can be implemented not only as a single-chamber tube that is to say with a single distributing or collecting space, but also as a multichamber tube. Thus, Figure 6 shows as an example a two-chamber tube 12 which contains two longitudinal ducts 13a, 13b separated from one another. Two rows of slots 14, 15 lying next to one another are introduced into the two-chamber tube 12, each row of slots being configured according to that of Figure 1 or one of the variants mentioned above in this respect and issuing in each case into one of the two longitudinal

ducts 13a, 13b.

As a further embodiment of the invention, a header tube may be provided, the tube interior of which is divided by one or more transverse partitions into a plurality of collecting spaces which succeed one another in the tube longitudinal direction and into which issue in each case one or more flat-tube ends which are inserted sealingly into associated header tube slots.